OUTLINE SHEET 3-13-1
Auxiliary Equipment

A. Introduction

Auxiliary machinery is used to support both the crew and propulsion equipment. This lesson will cover the basic information concerning the distilling plant, compressed air system and the refrigeration plant.

B. Enabling Objectives

3.40 **DESCRIBE** the purpose, major component parts, and basic principles of operation of a two stage flash type distilling plant .

3.41 **DESCRIBE** the purpose, major component parts, and basic principles of operation of a compressed air system.

3.42 **DESCRIBE** the classifications of compressed air systems.

3.43 **DESCRIBE** the safety precautions to be observed in the vicinity of compressed gases.

3.44 **DESCRIBE** the purpose, major component parts, and basic principles of operation of a refrigeration plant.

C. Topic Outline

1. Introduction
2. Overview
3. Distilling Plant
4. Refrigeration System
5. Compressed Air System
7. Summary and Review
8. Assignment

ASSIGNMENT SHEET 3-13-2
Auxiliary Equipment

A. Introduction

This material is to be completed prior to the material being covered in class.

B. Enabling Objectives

Refer to enabling objectives in Outline Sheet 3-13-1.

C. Study Assignment

1. Read Fireman NAVEDTRA 12001, pages 10-1 to 10-35.
2. Read Information Sheet 3-14-3

D. Study Questions

1. What is the purpose of drawing vacuum in the first and second stage evaporator shells?
2. How does the refrigerant absorb heat from the space being cooled?
3. What are the functions of the air receiver?

INFORMATION SHEET 3-13-3
Auxiliary Equipment

A. Introduction

This information describes auxiliary machinery.

B. Reference

Fireman NAVEDTRA 12001

C. Information

I. Auxiliary machinery is any system or unit of machinery that supports the main propulsion units or helps support the ship and the crew.
   A. For example:
      1. pumps
      2. evaporators (distilling plants)
      3. steering gear
      4. air conditioning and refrigeration equipment
      5. compressed air systems
      6. laundry and galley equipment
      7. deck winches
      8. anchor windlass
   B. This lesson will only cover:
      1. Two-stage Distilling Plant
      2. Compressed Air Systems
      3. Refrigeration Plants

II. Distilling Plants, commonly called evaporators or “evaps”, convert seawater to freshwater.
   A. The type most widely used throughout the Navy is the flash-type distilling plant. It uses steam to heat seawater and the resulting steam or vapor is condensed to produce drinkable water.
   B. Distilling plant terms and definitions:
      1. Evaporation - the process of turning water into vapor or steam. It is commonly referred to as “flashing” of water into steam.
      2. Brine - the portion of seawater that does not flash into steam. It has very high concentration of salt.
      3. Condensation - the process of cooling the vapor or steam to return it to liquid form.
      4. Distillate - practically pure water resulting from the condensation of the steam.

5. Vacuum - any pressure that is lower than atmospheric (14.7 psia).
   a) The lower the pressure (or the higher the vacuum) acting on the water, the lower its boiling point.
   b) The boiling point of water at atmospheric pressure is 212^{o}F. The boiling point of water at 28"Hg Vacuum is approximately 98^{o}F.

C. Major components of a two stage flash-type distilling plant:
1. Seawater feed pump - delivers seawater for conversion into usable fresh water.
2. First and second stage evaporator shells - maintained under relatively high vacuum. Also referred to as flash chambers because seawater "flashes" to steam as it enters these evacuated chambers.
3. Seawater heater - where seawater is heated prior to injection into the first stage shell.
4. Condenser - a set of cooling tubes located at the upper part inside the evaporator shells.
   a) Relatively colder seawater from the seawater feed pump is directed through these tubes.
   b) Steam that resulted from the flashing of the seawater condenses when it comes in contact with the cold external surfaces of these tubes.
5. Distillate trough - collects the water condensed from the steam.
6. Distillate pump - takes suction from the distillate trough and delivers the water to a suitable potable water tank for later use by the crew, or to a feedwater tank for use by the boilers.
7. Brine pump - removes brine that accumulates at the bottom of the evaporator shells and discharges it to the sea.
8. Air ejectors - jet pumps that help maintain vacuum inside the evaporator shell.

D. Principle of operation:
1. The seawater feed pump takes suction from the sea and discharges it at 20-40 psig.
2. Seawater is directed through the condenser. The steam inside the flash chambers condenses as it comes in contact with the colder tubes. The seawater inside the tubes picks up heat from the condensing steam.
3. From the condenser, the seawater is directed into the seawater heater where it is heated to 170^{o}F. This temperature is maintained because it is high enough to make seawater flash when injected into the vacuum inside the shells but not too high to promote formation of scale.

4. The preheated seawater is directed into the first stage shell where it flashes into steam because of the much lower pressure (vacuum) inside the shell.
5. Steam rises to the top of the flash chamber through the demisters. The demisters remove salt-laden moisture that may have carried over with the steam.
6. Steam condenses as it comes in contact with the condenser tubes
7. Condensed steam (distillate) collects in the distillate trough where it is pumped out by the distillate pump into a suitable tank.
8. Seawater that did not flash in the first stage gets drawn into the second stage where the distillation process is repeated. (Water is drawn into the second stage shell because it has a higher vacuum than the first stage).
9. The condensation of the steam into a much smaller volume of water creates most of the vacuum inside the evaporator shells. The air ejectors help maintain the vacuum and are set up so that vacuum is always higher in the second stage than in the first stage.
10. Brine that accumulates at the bottom of the flash chambers is removed by the brine pump.

III. Refrigeration Systems

A. Refrigeration is the process by which the temperature of a substance or a space is lowered below that of the atmosphere or surrounding materials.

B. The purpose of refrigeration is to maintain spaces at low temperatures to:
1. prevent spoilage of food
2. prevent overheating of electronic equipment
3. provide comfortable crew living and working spaces

C. Major components of the refrigeration plant:
1. Refrigerant - the medium used as the heat absorber or cooling agent. Most Navy refrigeration systems use R-12 (dichlodifluoromethane).
2. Compressor - keeps the refrigerant flowing through the system by pressurizing the vaporized refrigerant.
3. Condenser - removes the heat absorbed by the refrigerant from the space being cooled. It returns the refrigerant back to liquid state.
4. Receiver - acts as the temporary storage for the liquid refrigerant.
5. Thermostatic expansion valve - regulates the amount of refrigerant going into the cooling coil (evaporator) depending upon the temperature of the space being cooled.

6. Evaporator - the cooling coil of the refrigeration system. This is where the heat from the space being cooled is absorbed by the refrigerant.

D. Principle of operation
1. From the evaporator, refrigerant in vapor form enters the compressor.
2. The compressor converts this low pressure vapor into a high pressure vapor. The temperature of the refrigerant rises accordingly with the rise in pressure.
3. The condenser removes the heat from this high pressure, high temperature vapor and converts it into a high pressure, low temperature liquid. Condensers may be water cooled or air cooled.
4. The high pressure, low temperature liquid refrigerant collects in the air receiver.
5. The liquid refrigerant is allowed into the evaporator by the Thermostatic Expansion Valve (TXV). The TXV regulates the amount of refrigerant going into the evaporator. The warmer the space, the more refrigerant is needed. The colder the space, the less refrigerant is needed.
6. As the high pressure liquid refrigerant enters the evaporator, it expands into a low pressure vapor and its temperature drops accordingly (20^{o}F for R-12).
7. Heat from the space being cooled is absorbed by the cold refrigerant vapor flowing through the evaporator coils.
8. The refrigerant vapor leaves the evaporator, enters the compressor and the cycle is repeated.

IV. Compressed Air Systems

A. Compressed air is used aboard ships for the operation of various pneumatic tools and equipment, automatic boiler controls, diesel engine and gas turbine starting, air ballasting, torpedo charging and ejecting, etc.

B. Compressed air systems are classified as follows:
1. Low-pressure (LP) air - pressure of 150 psi or less.
2. Medium pressure (MP) air - 151 psi to 1000 psi.
3. High pressure (HP) air - above 1000 psi.

C. Major components of compressed air systems:
1. Compressor - the heart of any compressed air system.
a) It takes in atmospheric air and compresses it to the desired pressure.
b) The most commonly used type of compressor is the reciprocating type
2. Air coolers are used to remove the heat of compression from the compressed air.
a) Intercoolers cool the air as it passes from one stage to the next stage.

b) Aftercoolers cool the air as it leaves the final stage of the compressor.

3. Dehydrators are air dryers used to remove moisture from compressed air. Two types of dehydrators or the combination of the two are used in the Navy:
   a) Type I - uses refrigeration to condense the water vapor in the compressed air
   b) Type II - Uses desiccant to absorb water from the compressed air. Desiccant is a material with a high capacity to remove (absorb) water or moisture.
4. Air receivers and flasks are used:
   a) as storage tanks for compressed air.
   b) to minimize pressure pulsation within the system.
   c) to allow the compressor to shut-off during low or no demand for compressed air.

D. Principle of operation
1. Most compressors used in the fleet are designed to compress air in stages to achieve the final pressure.
2. Atmospheric air is taken into the first stage and compressed to a higher pressure
3. From the first stage, the air goes through an intercooler where heat of compression is removed.
4. The air then goes into the second stage where pressure is further increased.
5. For HP air compressors, the staging process is repeated five more times to achieve the final pressure.
6. For most LP compressors, the second stage is the final stage.
7. From the final stage, the air goes through another heat exchanger called the aftercooler where again, heat of compression is removed.
8. The air then goes through the dehydrator where moisture is removed.
9. Compressed air is then stored in the air receiver or air flask (for HP air).
10. Moisture that accumulates in the air coolers, dehydrators, and air receiver is drained manually, or automatically by solenoid operated valves.
11. Air used for various propulsion control devices and electronic equipment goes through dehydrators or air dryers to remove remaining moisture.
12. Air taken directly from the air receiver for the operation of pneumatic tools and other non-critical devices is distributed throughout the ship through the ship’s service air system.

V. Compressed gases.
   A. On Navy ships, numerous types of compressed gases are used. Examples are oxygen and acetylene for welding operations, FREON for air conditioning and refrigeration systems, and Nitrogen for purging and pressurization of various systems.
   B. Compressed gases are often stowed in cylinders and as such, have the potential for explosion, fire, and as a health hazard.
   C. The following are some general guidelines in handling compressed gases.
      1. Keep cylinder fittings free of flammable materials such as grease and oil.
      2. Securely fasten cylinders in vertical position.
      3. Never drop cylinders nor permit them to strike against each other violently.
      4. Caps must be kept on the cylinders when the cylinders are not being used
      5. Prior to disconnecting any part of an air system, make sure that the part is not under pressure.
      6. Many compressed gases become powerful freezing agents when depressurized. Wear necessary personal protective gear such as gloves and face shield whenever releasing compressed gas to the atmosphere.

DIAGRAM SHEET 3-13-4
Distilling Plant

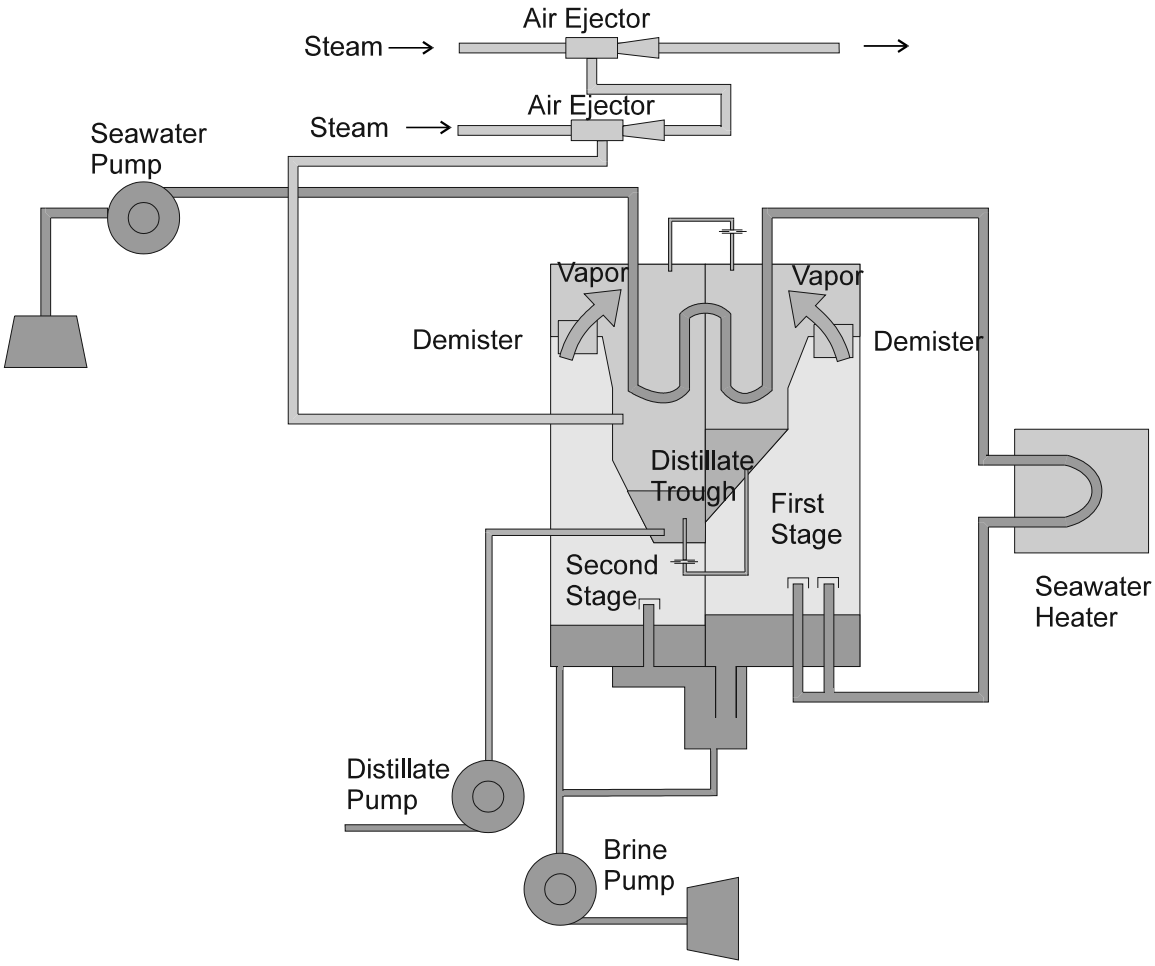

DIAGRAM SHEET 3-13-5
Refrigeration Cycle